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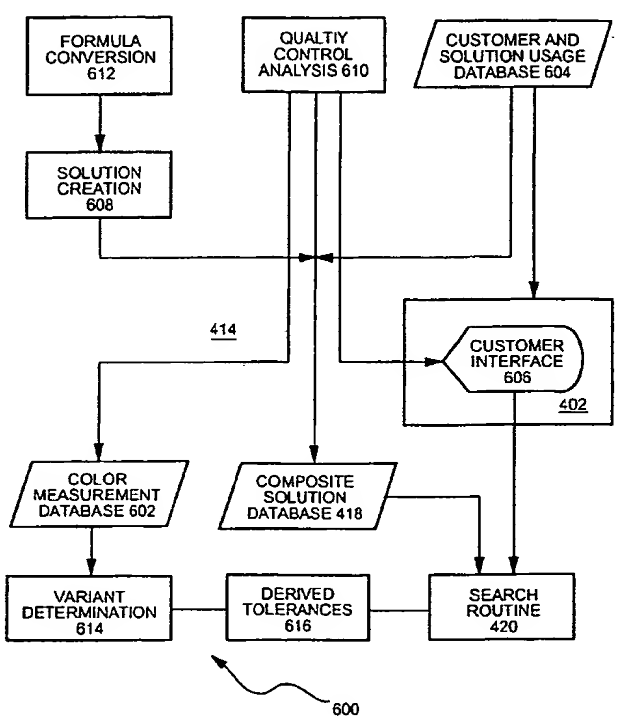
(54) Title: SYSTEM AND METHOD FOR DETERMINING ACCEPTABILITY OF PROPOSED COLOR SOLUTION USING AN ARTIFICIAL INTELLIGENCE BASED TOLERANCE MODEL



(57) Abstract: A system and method for determining if a proposed color solution, such as paint, pigments, or dye formulations, is acceptable, is provided. The inputs to the system are the color values of a proposed paint or other color formulation and differential color values. The system includes an input device for entering a proposed color solution and an artificial intelligence tolerance model coupled to the input device. The tolerance model produces an output signal for communicating whether the proposed color solution is acceptable. The artificial intelligence model may be embodied in a neural network. More specifically, the tolerance model may be a back propagation neural network.

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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EPO-Internal, WPI Data, PAJ, IBM-TDB, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 05470 A (EASTMAN KODAK CO) 2 April 1992 (1992-04-02)	1-5, 14-16, 24,33
Y	page 2, line 24 -page 5, line 10 page 10, line 8 -page 11, line 33 page 13, line 1 -page 14, line 5; figures 1-5 ---	21,38,39
Y	US 5 798 943 A (COOK ROBERT L ET AL) 25 August 1998 (1998-08-25) column 2, line 1 - line 36 column 2, line 60 -column 8, line 20; figures 1,4 ---	21,38
Y	WO 98 12520 A (WEA MFG INC) 26 March 1998 (1998-03-26) page 2, line 15 -page 3, line 3 page 3, line 19 -page 7, line 22 --- -/--	39

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schenkels, P

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 484 564 A (KANSAI PAINT CO LTD) 13 May 1992 (1992-05-13) column 1, line 10 -column 9, line 53; figures 1-3	21,38
A	US 6 088 475 A (NAGASHIMA ET AL) 11 July 2000 (2000-07-11) column 1, line 5 - line 10 column 2, line 36 -column 6, line 38 column 7, line 50 -column 9, line 29; figures 1,2	1,11

INTERNATIONAL SEARCH REPORT

Information on patent family members

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			CA	2072629	A1	18-03-1992
			DE	69125700	D1	22-05-1997
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			EP	0500926	A1	02-09-1992
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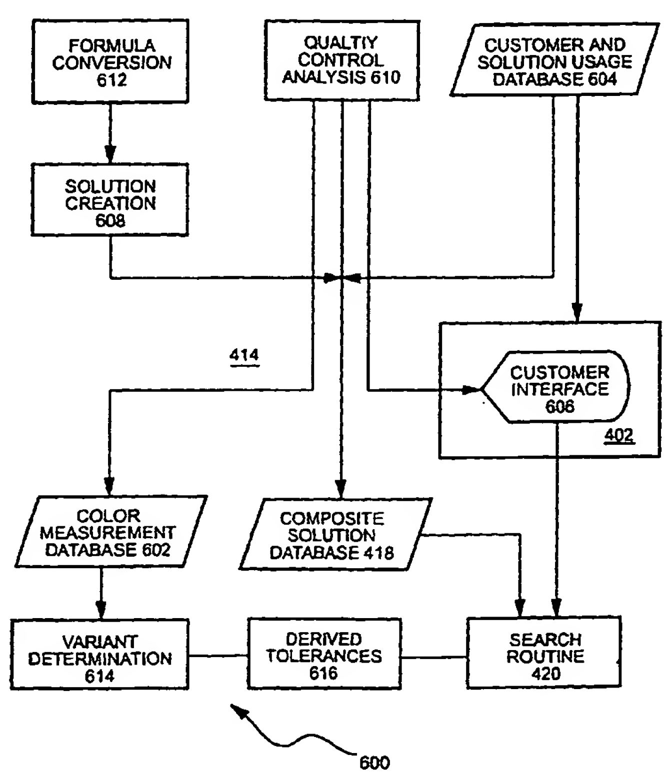

(57) **Abstract:** A system and method for determining if a proposed color solution, such as paint, pigments, or dye formulations, is acceptable, is provided. The inputs to the system are the color values of a proposed paint or other color formulation and differential color values. The system includes an input device for entering a proposed color solution and an artificial intelligence tolerance model coupled to the input device. The tolerance model produces an output signal for communicating whether the proposed color solution is acceptable. The artificial intelligence model may be embodied in a neural network. More specifically, the tolerance model may be a back propagation neural network.

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SYSTEM AND METHOD FOR DETERMINING ACCEPTABILITY OF PROPOSED COLOR SOLUTION USING AN ARTIFICIAL INTELLIGENCE BASED TOLERANCE MODEL

FIELD OF THE INVENTION

[0001] The present invention relates generally to color matching, and more particularly, to a method and system for assessing the acceptability of a color match using artificial intelligence.

BACKGROUND OF THE INVENTION

[0002] Products today are offered to consumers in a wide variety of colors. Consumer products may be colored by means of colorants or dye or painted. Color matching is required in a variety of areas, including textiles, plastics, various synthetic materials, prosthetics, dental applications, and paint applications, due to the many variations in color, and due to the wide variations in shades and hues of any given color and color variations in an article. The actual color produced in a given article may vary due to a number of factors. For example, textile colors vary according to fiber composition. Colorants for plastic vary according to the plastic composition. Painted articles vary in color depending on any number of factors, such as paint composition, variations in the paint application process, including application method, film thickness, drying technique and number of layers. An important application for color matching is in the area of automotive color matching. Frequent uses for color matching in automotive paint occur in matching the same color from different batches or matching similar colors from different manufacturers. Additionally, there is a requirement for color matching refinish paint to an OEM (original

equipment manufacture) color when a vehicle body panels are damaged and require repainting.

[0003] A paint manufacturer supplies one or more paint formulations for the original paint color to refinish paint shops. By supplying a plurality of formulations or variants for a particular color, the paint manufacturer accounts for those factors that affect the actual color. Matching of dyes or colorants for other applications is also done through formulations for a particular color. Typically, the formulations for a particular color are distributed on paper, microfiche, and/or compact disks (CD). A color tool, composed of swatches of the variants for each color may also be produced and delivered to each customer. The customer must select a formulation most closely matching the existing color of the article. This is typically done visually, i.e., by comparing swatches of paint or color to the part or in the case of paint, spraying a test piece with each formulation.

[0004] Different formulations are derived from actual data gathered by inspectors at various locations, e.g., the textile, plastic or automobile manufacturer or vehicle distribution point. The inspectors take color measurement readings from articles of a particular color. These readings are used to develop color solutions, i.e., different formulations for the same color.

[0005] There are several disadvantages to the present method of color matching. Conventional color laboratories that use human analysis to determine color matching require significant numbers of people, equipment and materials for identifying pigments and locating a close match from a database. In some cases, an existing formula may provide a close match. In

other cases, the formula must be adjusted, mixed, applied and compared to a standard. These steps are repeated until a suitably close match is found. In other cases, no match is found and a formula must be developed from scratch. Correction of the formula requires a highly skilled technician proficient in the interaction of light with several different pigments.

[0006] Moreover, traditional computer software that assists a technician has several disadvantages. Traditional computer software has not proven to be very effective on colors containing "effect pigments." This software is typically based on a physical model of the interaction between illuminating light and the colorant or coating. These models involve complex physics and do not account for all aspects of the phenomena. A traditional approach is to use a model based on the work of Kubleka-Munk or modifications thereof. The model is difficult to employ with data obtained from multi-angle color measuring devices. One particular difficulty is handling specular reflection that occurs near the gloss angle. Another deficiency of the Kubleka-Munk based models is that only binary or ternary pigment mixtures are used to obtain the constants of the model. Thus, the model may not properly account for the complexities of the multiple interactions prevalent in most paint or colorant recipes.

[0007] The present invention is directed to solving or more of the problems identified above.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0008] Acceptable tolerances vary depending on the color. Tolerances are expressed in differential color values, e.g., ΔL^*, ΔC^*, ΔH^*. The differential values will vary as a function of the color. Historically, these values have been determined manually, i.e., by visual evaluation. The tolerances for that formulation are determined as a function of all of the color measurement values that have been deemed acceptable (usually by visible methods).

[0009] In one aspect of the present invention, a system for determining the acceptability of a proposed color solution using an artificial intelligence tolerance model, is provided. The model is embodied in a neural network and, in particular, a feed-forward back propagation neural network. The color standard is expressed as color values (L^*,C^*,h^*). The neural network is trained using the color values for each formulation of each color and the differential color values from all acceptable measurements.

[0010] When a proposed color solution has been chosen by a search routine, the color values of the solution from a composite solution database and color measurement data taken from the subject part form the input to the neural network. The output of the neural network is whether or not the color solution is acceptable. The neural network can also be used in other color difference measuring systems to express acceptability of the measured color difference.

[0011] The neural network includes an input layer having nodes for receiving input data related to color values of the standard and differences between the color values of the standard and the color solution. Weighted connections connect to the nodes of the input layer and have coefficients for weighting the

input data. An output layer having nodes is either directly or indirectly connected to the weighted connections. The output layer generates output data that is related to the acceptability of the color match. The data of the input layer and the data from the output layer are interrelated through the neural network's nonlinear relationship.

[0012] Neural networks have several advantages over conventional logic-based expert systems or computational schemes. Neural networks are adaptive and provide parallel computing. Further, because neural responses are non-linear, a neural network is a non-linear device, which is critical when applied to non-linear problems. Moreover, systems incorporating neural networks are fault tolerant because the information is distributed throughout the network. Thus, system performance is not catastrophically impaired if a processor experiences a fault.

[0013] Another aspect of the present invention provides a system and a method for providing color solutions using an artificial intelligence tolerance model to a customer over a computer network. The system includes a first module located at a remote location. The first module receives a solution request from an operator. A second module is coupled to the first module via a computer network. The second module is located at a central location and includes a composite solution database, an artificial intelligence tolerance model and a search routine coupled to the composite solution database. The second module is adapted to receive the solution request from the first module. The search routine is adapted to search the composite solution database for a color code and determine a paint color solution from a plurality

of color solutions as a function of the solution request. The artificial intelligence tolerance model is adapted to determine if the color solution chosen by the search routine based on the color values of the solution input into the first module is acceptable.

[0014] The method includes the steps of receiving a solution request and color values from an operator located at a remote location, delivering the solution request and color values from the remote location to a central location over the computer network, and searching a composite solution database for a color solution and determining a whether the color solution as a function of the solution request is acceptable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0016] Fig. 1 is a block diagram of a system for determining the acceptability of a proposed color solution having an artificial intelligence model, according to an embodiment of the present invention;

[0017] Fig. 2 is a diagram depicting a neural network for use in the artificial intelligence model of Fig. 1, according to an embodiment of the present invention;

[0018] Fig. 3 is a block diagram depicting the training of the color tolerance neural network of Fig. 2, according to an embodiment of the present invention;

[0019] Fig. 4 is a block diagram of a color management and solution distribution system, according to an embodiment of the present invention;

[0020] Fig. 5 is a flow diagram of a color management and solution distribution method, according to an embodiment of the present invention; and

[0021] Fig. 6 is a block diagram of a color management and solution distribution method, according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] Referring to the Figs., wherein like numerals indicate like or corresponding parts throughout the several views, a system 100 and method 600 for determining if a proposed color solution, such as paint, pigments, or dye formulations, is acceptable, is provided.

[0023] For example, the proposed color solution may be a paint formulation to be used in the repair of an automobile body panel. The inputs to the system are the color values (see below) of a proposed paint formulation and differential color values. The differential color values represent the differences between the color values of the proposed paint formulation and the actual color values of the part to be repaired.

[0024] With specific reference to Fig. 1, the system 100 includes an input device 102 for entering a proposed color solution. Preferably, the system 100 is embodied in a computer program run on a general purpose computer (not

shown). The input device 102 may be embodied in a user interface for inputting the proposed color solution, such as a keyboard. Furthermore, the input device 102 may be embodied in an element of a computer system so as to receive the proposed color solution as input from another element of the computer system, such as a computer database, an electronic mail file or other suitable element of the computer system (see below).

[0025] The system 100 of the present invention further includes an artificial intelligence tolerance model 104 coupled to the input device 102. The tolerance model 104 produces an output signal 106 for communicating whether the proposed color solution is acceptable. The artificial intelligence model 104 may be embodied in a neural network. More specifically, the tolerance model 104 may be a back propagation neural network or any other suitable neural network. The output signal 106 may be embodied in an acceptable/not acceptable format, an acceptance factor format or any other suitable format.

[0026] The proposed color solution includes color measurement data in the form of color values. Color measurement data is an indication of the actual color of an object. Preferably, the color measurement data may be determined using a multi-angle or spherical geometry color measuring device, a spectrophotometer, digital camera or other suitable device.

[0027] Color values refer to color attributes used to quantify color. The color values may include color space values, reflectance values or other suitable color attributes. One example of color space values are defined by $L^*a^*b^*$, where L^* represents luminous intensity, a^* represents a red/green appearance,

b* represents a yellow/blue appearance. Another example of color space values are defined by L*, C*, h, where L* represents lightness, C* represents chroma, and h represents hue. The color values (L*, a*, and b* or L*, C*, and h) at various angles are obtained using a color measurement device.

[0028] Referring to Fig. 2, an artificial neural network is generally shown at 200. Artificial neural networks 200 are computing systems that model vertebrate brain structure and processes. Artificial neural network techniques are a member of a group of methods which fall under the umbrella of artificial intelligence. Artificial intelligence is commonly associated with logic rule-based expert systems where the rule hierarchies used are reasoned from human knowledge. In contrast, artificial neural networks 200 are self-trained based on experience acquired through data compilation and computation. Thus, artificial intelligence utilizing neural networks 200 is particularly useful in conjunction with complex systems or phenomena where the analysis is complicated, and deriving a model from human knowledge for use in a conventional expert system is a daunting task.

[0029] Although neural networks differ in geometry, activation function and training mechanics, they are typically organized into at least three layers. The first layer is an input layer 220 having one or more input nodes 224, 226, 228. The second layer is an output layer 260 having one or more output nodes 264, 266, 268. Each output node 264, 266, 268 corresponds with an input node 224, 226, 228. Between the inner and outer layers, there are one or more hidden layers 240, each having one or more hidden nodes 244, 246, 248 corresponding to an input node and output node pair 224,264, 226, 266, 228,

268. Each input variable is associated with an input node 224, 226, 228 and each output variable is associated with an output node 264, 266, 268. Within the neural network 200, data flows in only one direction, such that each node 224, 226, 228, 244, 246, 266, 268 only sends a signal to one or more nodes and receives no feedback.

[0030] The enabling power of a neural network 200 is its connectivity, or the connections between the various nodes 224, 226, 228, 244, 246, 266, 268. (A configuration technique modeled after the structure of the human brain.) Moreover, because the network is structured, or connected, in such a way as to provide parallel processing (where each node 224, 226, 228, 244, 246, 266, 268 has connections with other nodes 224, 226, 228, 244, 246, 266, 268), it is extremely efficient at acquiring and storing experiential knowledge and, then recalling and using that knowledge. More specifically, a node 224, 226, 228, 244, 246, 266, 268 receives input values, processes them and provides an output. The processing step includes summing the inputs, adding a bias value and submitting this total input to an activation function which limits the magnitude of the output. The connections between the various nodes 224, 226, 228, 244, 246, 266, 268 are weighted. An output sent from one node 224, 226, 228, 244, 246, 266, 268 to another is multiplied by the weighting factor associated between those two particular nodes 224, 226, 228, 244, 246, 266, 268. The weighting factor represents the knowledge of the system. The system continues to accumulate knowledge and adjust the weighting factor in accordance with training and the further acquisition of knowledge by the

network 200. Consequently, the output of the network 200 agrees with the experience of the network 200.

[0031] With particular reference to Fig. 1, the output of the tolerance model 104 may be communicated to a logic module 102 for transforming the output signal 106 into a desired format. The desired format of the output signal 106 may take the form of a single continuous variable, a fuzzy variable set or any other suitable format.

[0032] A single continuous variable is a variable that may assume any value between two endpoints. An example being the set of real numbers between 0 and 1.

[0033] A fuzzy variable set is the basis for a mathematical system of fuzzy logic. "Fuzzy" refers to the uncertainty inherent in nearly all data. Fuzzy logic may be used in artificial intelligence models, specifically neural networks, because there is a fuzziness in the output of the neural network. Fuzzy logic is based on fuzzy variables. Inputs to a neural network may be provided for the fuzziness associated with each network parameter. An output parameter depicting the fuzziness of the result could also be incorporated into the neural network. The output parameter could range in value from 0 to 1, with a 1 indicating no uncertainty in the result. For example, when gauging color match quality, there may be uncertainty in the measurement of the color values and in the descriptive value of the goodness of the match. A fuzzy variable set as an output signal from the neural network indicates the level of uncertainty and the quality level of the result. Thus, the quality and confidence of a color

match may be expressed as 0.9, 0.8, where the quality is rated as very good at 0.9 and the confidence, or level of certainty, is quite high at 0.8.

[0034] With particular reference to Fig. 4, the neural network 104 of the subject invention is trained using the color values for each formulation of each color and all acceptability results. There are two different types of training (learning) for a neural network 104. In supervised training (or external training), the network 104 is taught to match its output to external targets using data having input and output pairs. In supervised training, the weighting factors are typically modified using a back-propagation method of learning where the output error is propagated back through the network 104. In unsupervised training (or internal training), the input objects are mapped to an output space according to an internal criteria.

[0035] Referring to Fig. 3, in the preferred embodiment of the subject invention neural network 104 is a back propagation neural network 104. The training of the back propagation neural network 104 will now be discussed. In a first process block 402 color values are provided to an artificial intelligence cluster model. In a second process block the artificial intelligence cluster model determines if the color solution is acceptable. In a third process block 306, an output signal is produced (see above).

[0036] In a fourth process block 308, acceptance ratings are input and transformed into a desired format (fifth process block 310).

[0037] In a sixth process block 312, the transformed acceptance ratings are input and compared to the output signal 106 of the neural network 104. In a first decision block 314, if the output signal 106 is within accepted tolerance

limits, no further action is taken. However, where the output signal 106 is outside the accepted tolerance limit, the plurality of weighted factors are adjusted based on the acceptance factor output at the output signal 106 in a seventh process block 316.

[0038] With reference to Fig. 4, another embodiment of the present invention provides a computer system 400 for managing and providing color solutions, such as paint, pigments or dye formulations. The system 400 includes a first module 402 located at a remote location 404, such as a customer site. Preferably, the first module 402 is implemented on a computer (not shown), such as a personal computer or wireless computing device. The first module 402 is adapted to be operated by a user or operator 406, i.e., the customer. The operator 406 inputs a solution request to the first module 402. The solution request includes a paint or color identifier (or color code) which identifies the color of a sample or painted substrate 408, and color measurements from a color measurement device 410.

[0039] The color measurement device 410 is used to provide color measurements, i.e., an indication of the actual color of the sample 408. Preferably, the color measurement device 410 is a spectrophotometer such as is available from X-Rite, Incorporated of Grandville, MI as model no. MA58. Alternatively, the color measurement device 410 may be a spherical geometry color measuring device, a digital camera or other suitable device.

[0040] The first module 402 is coupled to a second computer based module 412 located at a central location 414, such as the paint, dye or colorant manufacturer's facility. The first and second computer based modules 402,

412 are coupled across a computer network 416. In the preferred embodiment, the computer network 416 is the internet.

[0041] The second module 412 receives the solution request from the operator 406 via the first module 402 and the computer network 416. The second module 412 includes a composite solution database 418, a search engine or routine 420, and an artificial intelligence tolerance model 422. The search routine 420 is adapted to search the composite solution database 418 and determine a paint color solution as a function of the solution request. The artificial intelligence tolerance model 422 is adapted to determine if the color solution, chosen by the search routine 420 based on the color values of the solution input into the first module 402, is acceptable.

[0042] With reference to Fig. 5, a computer based method 500 for providing color solutions to a customer will now be explained. In a first control block 502, color values and, the solution request from the operator 406 located at the remote location 404 is received. In a second control block 504, the solution request and color values are delivered over the computer network 416 from the remote location 404 to the central location 404. In a third control block 506, the composite solution database 418 is searched for a color solution and the acceptability of the color solution is determined.

[0043] With particular reference to Fig. 6, a system 600 for managing and providing color solutions using derived color tolerances is provided. The system 600 includes three databases: the composite solution database 418, a color measurement database 602, and a customer and solution usage database 604.

[0044] A customer interface 606 is implemented on the first module 402 located at the remote location 604. The customer interface 606 allows the operator 406 to log on to the system, communicate with the system 400,600, e.g., to request color solutions, to communicate color values and color measurement data, and to receive color solutions from the system 400,600. The customer interface 606 is graphical in nature, and, preferably, is accessed through a generic world wide web (WWW) browser, such as Microsoft™ Internet Explorer, available from Microsoft of Redmond, Washington.

[0045] The customer interface 606 may be implemented in hyper text markup language (HTML), the JAVA language, and may include JavaScript. The system 600 also includes several processes: a solution creation process 608, a quality control process 610, a formula conversion process 612, a variant determination process 614, and a derived tolerance process 616.

[0046] Referring to Figs. 1 and 2, the artificial intelligence tolerance model 100 of the subject invention is embodied in a neural network 104. The tolerance model neural network 104 includes input data from the input device 102 in the form of a proposed color solution having color values. When a proposed color solution has been chosen by the search routine 420, the color values of the solution from the composite solution database 418 form the input to the tolerance model neural network 406. The neural network 200 determines whether the proposed color solution is within the learned color tolerances and, thus, deemed acceptable.

[0047] Specifically, the subject invention neural network 200 includes an input layer 220 having a plurality of input nodes 224, 226, 228 for receiving a

color solution having color values. The subject invention neural network 200 further includes an output layer 260 having a plurality of output nodes 264, 266, 268 for providing an acceptance factor of the color solution wherein one of the plurality of input nodes 224, 226, 228 corresponds with one of the plurality of output nodes 264, 266, 268. The subject invention neural network 200 further includes a hidden layer 240 having a plurality of weighted factor nodes 244, 246, 248 wherein one of the plurality of weighted factor nodes 244, 246, 248 corresponds to one of the plurality of input nodes 224, 226, 228 and the corresponding one of the plurality of output nodes 264, 266, 268. The plurality of weighted factors non-linearly determine the contribution of the color values to the acceptance factor.

CLAIMS

What is claimed is:

1. A computer-based system for determining whether a proposed color solution is acceptable , comprising:

an input device for receiving the proposed color solution, the proposed color solution including color values; and

an artificial intelligence tolerance model coupled to the input device for producing an output signal for communicating whether the proposed color solution is acceptable.

2. A computer-based system, as set forth in claim 1, wherein the artificial intelligence tolerance model is a neural network.

3. A computer based system, as set forth in claim 2, wherein the neural network is a back propagation neural network.

4. A computer-based system, as set forth in claim 2, wherein the neural network includes an input layer having a plurality of input nodes for receiving the proposed color solution and an output layer having a plurality of output nodes and one of the plurality of input nodes.

5. A computer-based system, as set forth in claim 4, wherein the neural network includes a hidden layer having a plurality of weighted factors wherein

one of the plurality of weighted factors corresponds to one of the plurality of input nodes and a corresponding output node.

6. A computer-based system, as set forth in claim 5, wherein the plurality of weighted factors determine the contribution of the color values to the output signal.

7. A computer-based system, as set forth in claim 6, wherein the plurality of weighted factors are adjusted as a function of the output signal.

8. A computer-based system, as set forth in claim 7, wherein the output signal is an acceptance factor.

9. A computer-based system, as set forth in claim 8, including an acceptance comparator for comparing the acceptance factor from the output layer to an acceptance standard and providing feedback.

10. A computer-based system, as set forth in claim 9, wherein the plurality of weighted factors are adjusted as a function of the feedback received by the input layer from the acceptance comparator.

11. A computer-based system, as set forth in claim 1, including a logic module for transforming the output nodes into a desired format.

12. A computer-based system, as set forth in claim 10, wherein the desired format is a single continuous variable.

13. A computer-based system, as set forth in claim 10, wherein the desired format is a fuzzy variable set.

14. An artificial intelligence based tolerance model for color solutions, comprising:

an input layer having a plurality of input nodes for receiving a proposed color solution, the proposed color solution having color values; and

an output layer having a plurality of output nodes wherein one of the plurality of input nodes corresponds with one of the plurality of output nodes;

wherein the output layer produces an output signal communicating whether the color solution is acceptable.

15. An artificial intelligence model, as set forth in claim 14, wherein the model is a back propagation neural network.

16. An artificial intelligence model, as set forth in claim 14, including a hidden layer having a plurality of weighted factors wherein one of the plurality of weighted factors corresponds to one of the plurality of input nodes and the corresponding one of the plurality of output nodes.

17. An artificial intelligence model, as set forth in claim 16, wherein the plurality of weighted factors determine the contribution of the color values to the output signal.

18. An artificial intelligence model, as set forth in claim 17, wherein the plurality of weighted factors are adjusted according to the output signal.

19. An artificial intelligence model, as set forth in claim 18, wherein the output signal is feedback at the input layer.

20. An artificial intelligence system, as set forth in claim 19, wherein the plurality of weighted factors are adjusted as a function of the feedback received by the input layer.

21. A computer system for providing a color solution to a customer, comprising:

a first module located at a remote location and being adapted to receive a solution request from an operator;

a second module coupled to the first module and being located at a central location, the second module including a composite solution database and a search routine coupled to the composite solution database and being adapted to receive the solution request from the first module, the search routine being adapted to search the composite solution database and determine a proposed color solution as a function of the solution request; and,

an artificial intelligence model for determining the acceptability of the proposed color solution

22. A computer system, as set forth in claim 21, wherein the artificial intelligence model is a neural network.

23. A computer system, as set forth in claim 22, wherein the artificial intelligence model is a back propagation neural network.

24. A method for determining the acceptability of a proposed color solution using an artificial intelligence model, including the steps of:

providing the proposed color solution to the model, the proposed solution having color values; and

producing an output signal indicative of whether the proposed color solution is acceptable.

25. A method, as set forth in claim 24, including the step of determining the contribution of the color values to the output signal.

26. A method, as set forth in claim 25, including the step of using a weighted factor to determine the contribution of the color values to the output signal.

27. A method, as set forth in claim 26, including the step of comparing the output signal to an acceptance standard.

28. A method, as set forth in claim 27, including the step of training the artificial intelligence model for determining acceptability.

29. A method, as set forth in claim 28, wherein the artificial intelligence model is a neural network and the method includes the step of providing feedback to the neural network from the output signal for adjusting the weighted factor.

30. A method, as set forth in claim 27, including the step of transforming the output signal into a desired format.

31. A method, as set forth in claim 27, including the step of transforming the output signal into a single continuous variable.

32. A method, as set forth in claim 27, including the step of transforming the output signal into a fuzzy variable set.

33. A method for determining the acceptability of a proposed color solution using a computer based model, the model being embodied in a neural network having an input layer and an output layer, including the steps of:

providing the proposed color solution to the neural network, the proposed color solution having color values; and

producing an output signal indicative of whether the color solution is acceptable.

34. A method, as set forth in claim 32 including the step of using a weighted factor to determine the contribution of the color values to the output signal.

35. A method, as set forth in claim 33 including the step of adjusting the weighted factor according to the output signal.

36. A method, as set forth in claim 34, including the step of providing feedback from the output signal to the input layer.

37. A method, as set forth in claim 35 including the step of adjusting the weighted factor according to the feedback received by the input layer.

38. A computer-based method for providing a color solution to a customer over a computer network, including the steps of:

receiving a solution request from an operator located at a remote location;

delivering the solution request from the remote location to a central location over the computer network;

searching a composite solution database and determining a proposed color solution as a function of the solution request;

providing an artificial intelligence system for determining the acceptability of the proposed color solution and responsively producing an output signal.

39. A method for training a neural network having an input layer, a hidden layer, and an output layer, the neural network being adapted to determine the acceptability of a proposed color solution, comprising the steps of:

providing a plurality of acceptable color solutions to the input layer, the acceptable color solutions having color values;

using a weighted factor to the color values in the hidden layer to produce an output signal;

providing the output signal to a comparator;

providing an acceptance standard to the comparator to compare the acceptance standard and the output signal for producing an error value;

comparing the error value to an error limit to determine error variation; and

providing error feedback to the neural network corresponding to the error variation, wherein the weighted factor is adjusted according to the error feedback.

FIG - 1

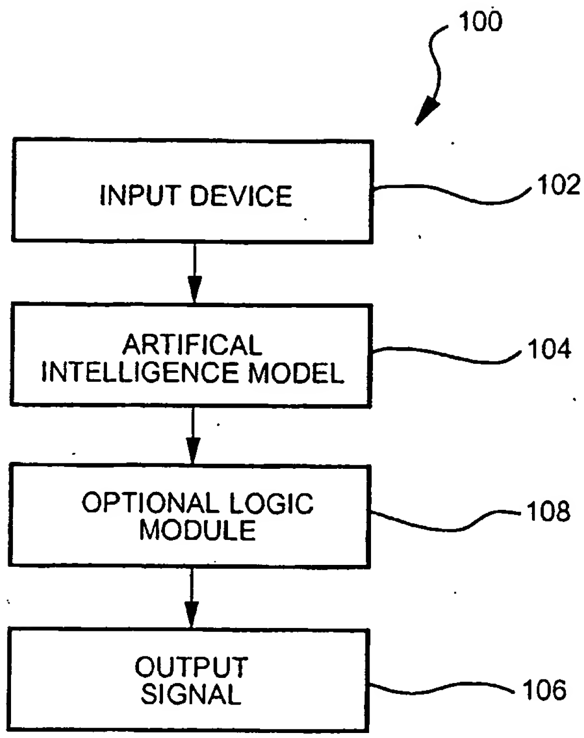

100
INPUT DEVICE
102
ARTIFICAL INTELLIGENCE MODEL
104
OPTIONAL LOGIC MODULE
108
OUTPUT SIGNAL
106

FIG - 2

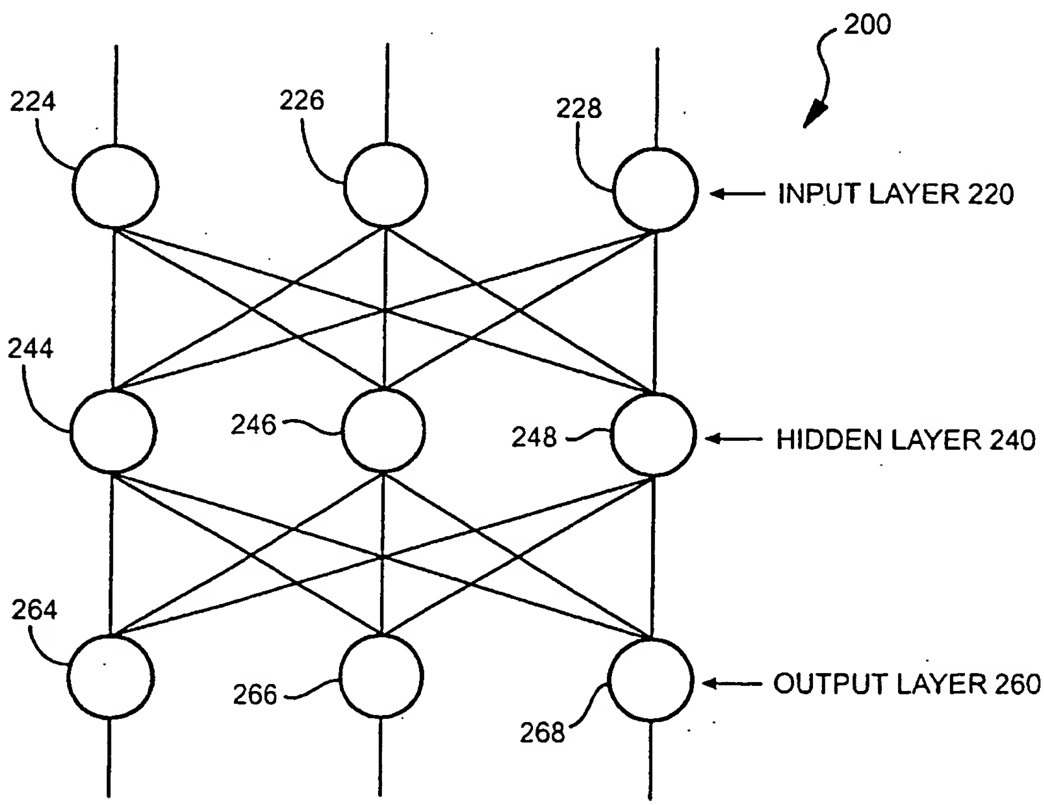
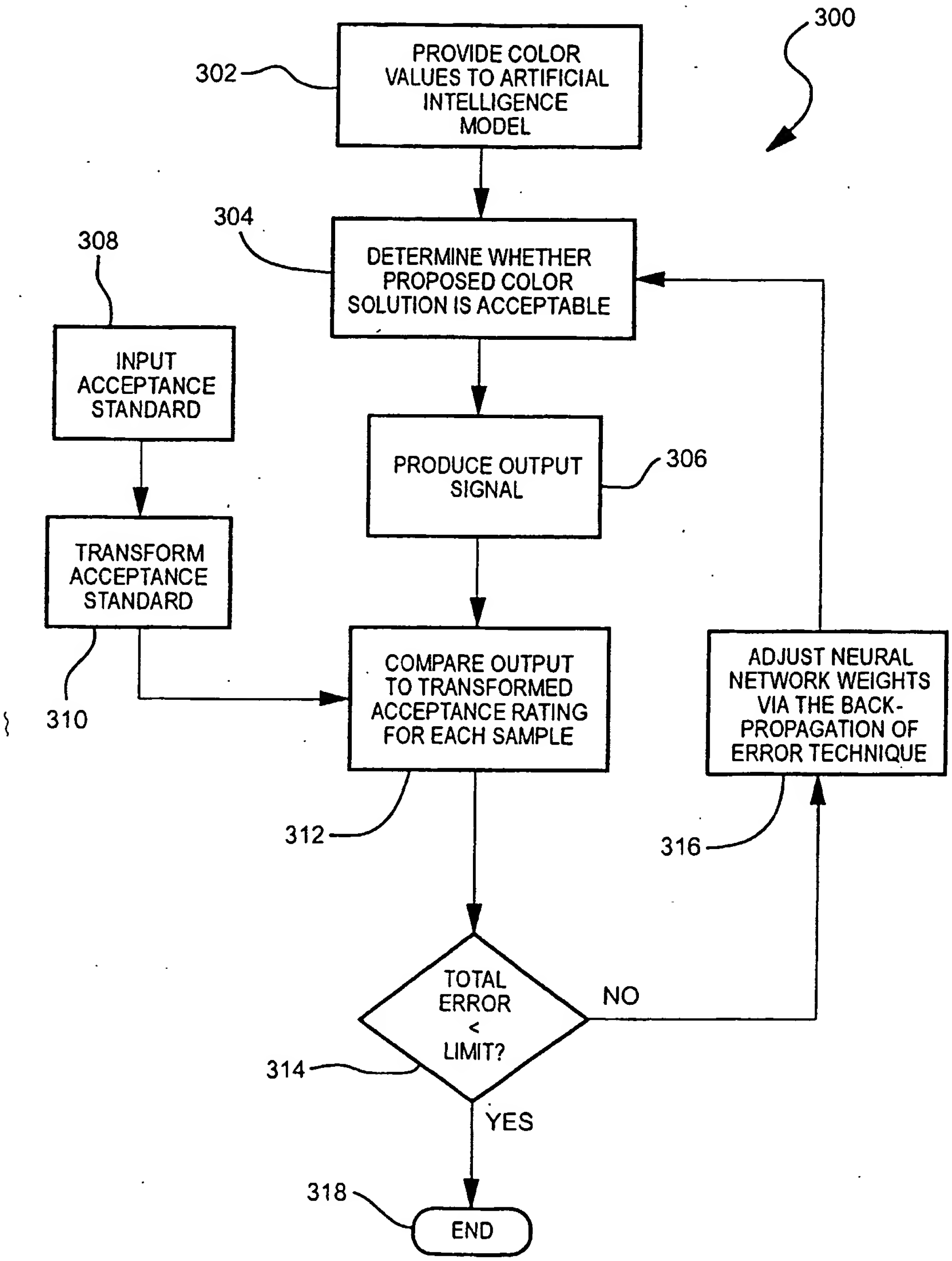

200
224
226
228
INPUT LAYER 220
244
246
248
HIDDEN LAYER 240
264
266
268
OUTPUT LAYER 260

FIG - 3


300
302
PROVIDE COLOR VALUES TO ARTIFICIAL INTELLIGENCE MODEL
304
DETERMINE WHETHER PROPOSED COLOR SOLUTION IS ACCEPTABLE
308
INPUT ACCEPTANCE STANDARD
PRODUCE OUTPUT SIGNAL
306
TRANSFORM ACCEPTANCE STANDARD
310
COMPARE OUTPUT TO TRANSFORMED ACCEPTANCE RATING FOR EACH SAMPLE
ADJUST NEURAL NETWORK WEIGHTS VIA THE BACK-PROPAGATION OF ERROR TECHNIQUE
312
316
TOTAL ERROR < LIMIT?
NO
314
YES
318
END

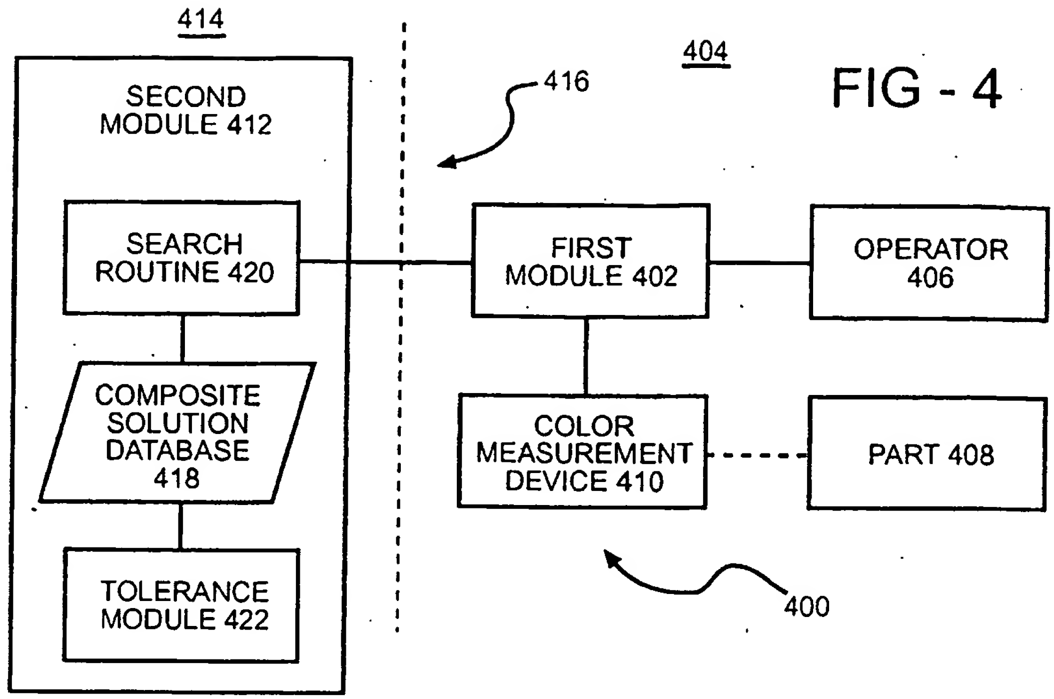

414
404
416
SECOND MODULE 412
SEARCH ROUTINE 420
COMPOSITE SOLUTION DATABASE 418
TOLERANCE MODULE 422
FIRST MODULE 402
OPERATOR 406
COLOR MEASUREMENT DEVICE 410
PART 408
400

FIG - 4

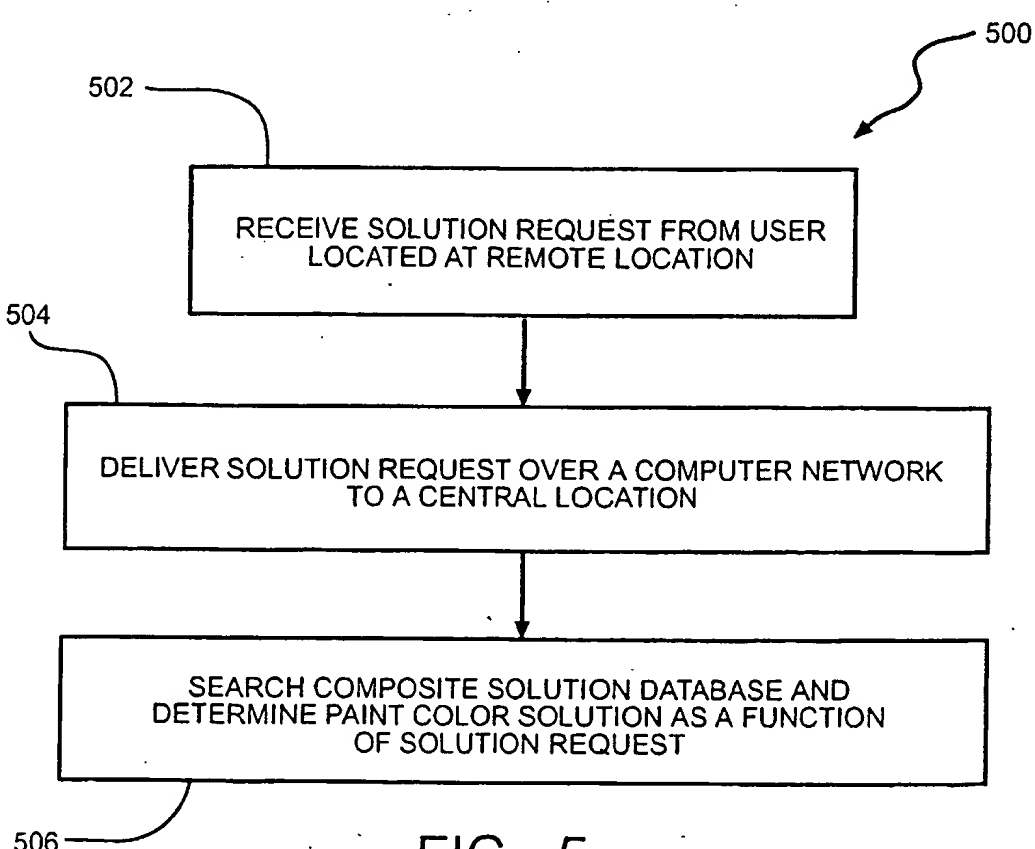
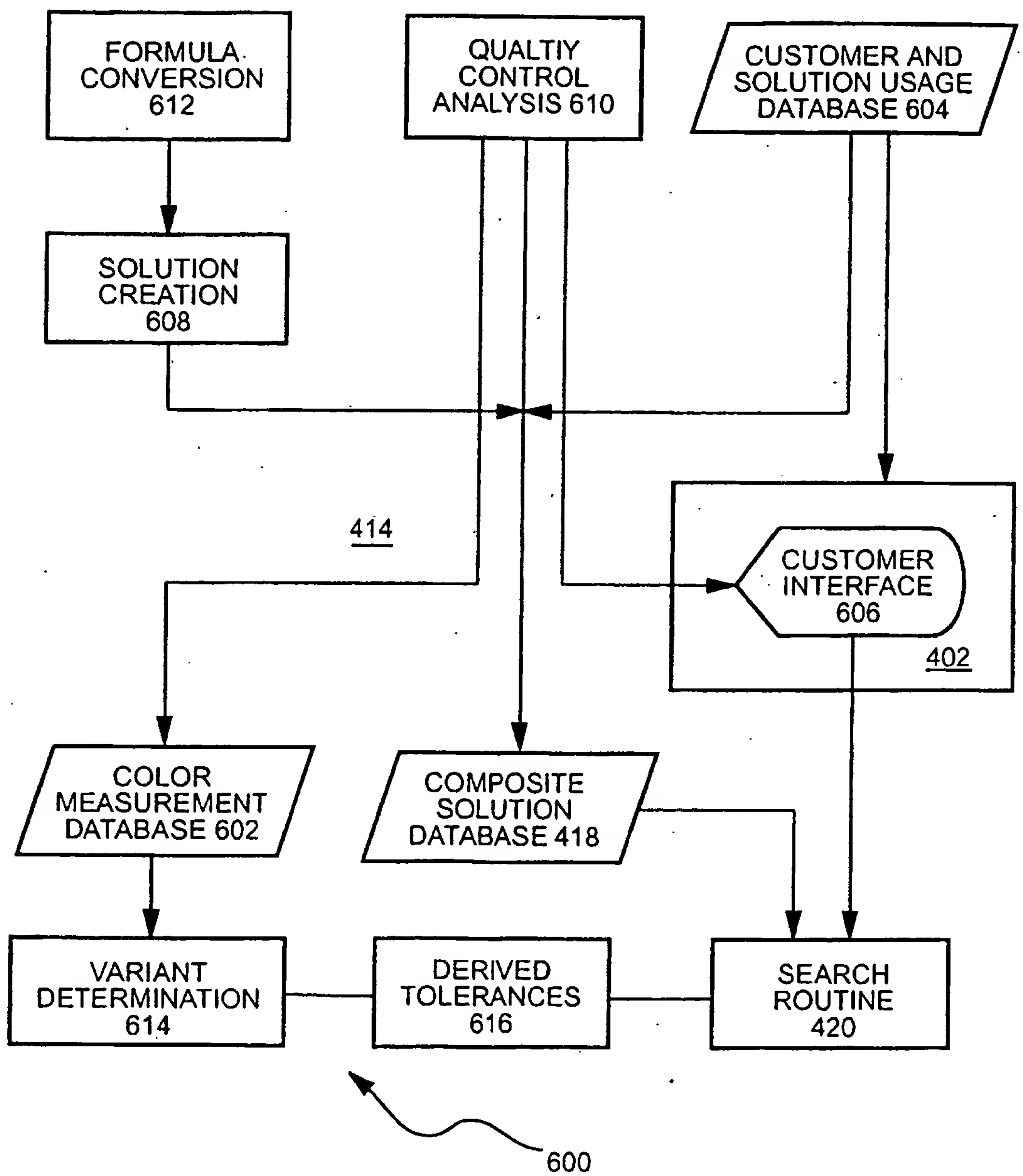

500
502
RECEIVE SOLUTION REQUEST FROM USER LOCATED AT REMOTE LOCATION
504
DELIVER SOLUTION REQUEST OVER A COMPUTER NETWORK TO A CENTRAL LOCATION
SEARCH COMPOSITE SOLUTION DATABASE AND DETERMINE PAINT COLOR SOLUTION AS A FUNCTION OF SOLUTION REQUEST
506

FIG - 5

FIG - 6


FORMULA CONVERSION 612
QUALTIY CONTROL ANALYSIS 610
CUSTOMER AND SOLUTION USAGE DATABASE 604
SOLUTION CREATION 608
414
CUSTOMER INTERFACE 606
402
COLOR MEASUREMENT DATABASE 602
COMPOSITE SOLUTION DATABASE 418
VARIANT DETERMINATION 614
DERIVED TOLERANCES 616
SEARCH ROUTINE 420
600